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On some Diffraction Experiments of M. Ch. André with reference to Astronomical Instruments, and the General Theory of this Diffraction. By the Rev. S. J. Perry.

My attention was first called to these experiments during a visit I paid this year to France; and whilst in Paris I had the pleasure of observing with the instruments, and of noting the extreme care with which the experiments are being made under the most favourable circumstances. Some of the experiments are confirmatory of results already noted by other astronomers, as by Sir W. and Sir J. Herschel and the Rev. W. Dawes, whilst others, as well as the complete theory of the subject, are, as far as I am aware, due entirely to the labours of M. André.

The image of a luminous point in the focus of a telescope is known to be a central disk surrounded by bright rings, the diameter of the disk varying inversely as the aperture of the object-glass or mirror employed. Hence the limitation to the separating power of a given instrument. If, however, the centre of the field is covered, the diameter of the focal disk diminishes as the diaphragm is increased. The separating power is thus augmented, but the ratio of the intensity of the bright rings to that of the central disk is proportionately increased.

If we draw a curve, whose ordinates represent the intensity of the light of each point of the image, and whose abscissas are the angular distances of these points from the axis of the telescope, this intensity curve, drawn for any particular aperture, will hold good for any other aperture, provided the unit for the abscissas is made inversely proportional to the aperture. A revolution of this intensity curve round its vertical axis will form what M. André calls the Solid of Diffraction; and if the axis of this solid coincides with that of the telescope, the quantity of light on any element of the focal plane is proportional to the cylindrical portion of the volume of the solid of diffraction, the base of the right cylinder being the given element.*

When the object is of finite dimensions, instead of being a luminous point, there is no interference of the rays from the different points, but the intensity of the light at any part of the image is the sum of the intensities of the separate elements. Hence we obtain the following theorem:—If the solid of diffraction, corresponding to the aperture employed, be placed so that its axis, which is perpendicular to the focal plane, passes through a point (m), the cylindrical portion of the solid, comprised within the geometrical image of the object, measures the intensity of (m).

Applying this theorem to objects of different dimensions, we find that the intensity of the image of a brilliant straight line is measured by the surface of a section of the diffraction solid;

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* The width of the solid of diffraction varies inversely as the aperture of the telescope.

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and that if the straight line is widened into a band, the measure of the intensity of the image is the volume of the same solid comprised between two sections, which widen out in the same proportion as the luminous band. Taking the more practical case of an object whose diameter is so considerable in every direction that we may consider the boundary lines as straight, we easily see that the focal image consists of two parts:

One similar to its geometrical image, depending on its form and apparent dimensions, but increasing with the aperture; the intensity being constant and maximum throughout:

The other overlapping and surrounding the first, its shape varying with that of the object, but its angular dimensions depending solely on the aperture. The intensity of this portion of the focal image, decreasing progressively, is reduced to one half at the limits of the geometrical image, and then quickly becomes insensible.

To find the intensity at the different points of this zone of diffracted light, which surrounds the geometrical image of any object of sufficient apparent magnitude, we must calculate the successive portions of the volume of the solid of diffraction intersected by a plane, which keeps parallel to the axis of the solid, whilst it moves from one edge of the zone to the other. As the extent of the zone of diffracted light bears a constant ratio to the maximum intensity of the focal image, the diameter of any body of sufficient brilliancy, observed on the same background, varies with the aperture. Thus for a 4-in. aperture the angular measure of the zone of diffracted light is 1″·4, on the supposition that light, reduced to $\frac{1}{30}$th of the central portion, ceases to affect the retina sensibly. Diameters are thus increased 2″·8 by a 4-in. telescope. This correction, called the Constant of Instrumental Diffraction, differs from the separating power of the telescope, and varies with the aperture of the telescope and the brilliancy of the object.

In order to verify experimentally these theoretical results, a hole was made in a piece of silvered copper, and a strong light from a Drummond lamp thrown upon it. Observing this by direct and reflected light, differences of 5″·82, 8″·87, and 13″·60, were found with apertures of 6·5, 2·9, and 1·7 centimeters.

A more accurate verification was made with a piece of blackened brass, in which two rectangular apertures had been carefully cut with bevelled edges, 3 centimeters in height by 1·5 in breath, and 1·5 apart. Direct light was alone used, and with apertures of 6·5, 3·0, and 1·7 centimeters, the exterior diameters were found to be 121″·15, 122″·17, and 125″·86, and the interior ones only 36″·13, 34″·48, and 31″·46, respectively.

Measures of the diameters of *Mercury* and *Venus*, whilst the planets were crossing the solar disk, also lead to the same conclusions.

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Thus, in the Transit of—

		Observer.	Instrument.	Aperture.	Diameter measured.	Reduced to Unity of Dist.
Mercury	4, 5 May 1832	Bessel	Heliometer	0·160	11·987	6·697
		Gambart	Equatoreal	0·070	9·290	5·184
„	8 May 1845	Mitchel	„	0·265	11·580	6·522
„	„	Mädler	„	0·224	11·754	6·542
„	„	Schmidt	„	0·068	10·853	6·057
„	8, 9 Nov. 1848	Arago	„	0·162	10·155	
„	„	Dawes	„	0·102	9·389	
„	„	„	„	0·072	9·369	
„	4 Nov. 1868	Wolf	„	0·204	9·430	6·367
„	„	Plummer	„	0·165	9·001	6·077
„	„	Struve	„	0·064	6·840	4·618
Venus	8 Dec. 1874	Mouchez	„	0·217	64·992	16·992
„	„	Tennant	„	0·152	63·948	16·904

Calculating the constant of instrumental diffraction for a 4-in. telescope from the last observations of *Mercury* and *Venus*, we obtain a mean value of 2″·634, which agrees closely with the theoretical value of 2″·80. If we compare the above diameters with measures taken at other times, we find that the diameter invariably decreases with the brilliancy of the background.

The corrections applied to the lunar diameter, when reduced from occultations of stars by the Moon, observed at the Royal Observatory with the East Equatoreal, affords another confirmation of the correctness of the preceding conclusions. The correction adopted for stars observed at the dark limb is − 2″·54, and at the bright limb − 0″·80; the difference is, therefore, 1″·74, whilst theory would give for the same instrument 1″·55.

When we increase the separating power of a lens by means of a central diaphragm, the constant of instrumental diffraction is increased, on account of a change in the form of the solid of diffraction, consisting in an increase of the relative volume of the parts external to the first minimum of intensity. If the aperture is thus reduced to ½, the decrease of light ceases to be continuous, and the constant of instrumental diffraction increases for a 4-in. telescope from 2″·8 to 4″·0. This has been verified by observations of the Moon and also of artificial objects.

As the mathematical theory of the subject has been worked out fully in a published essay, it would be out of place to enter into the question here, especially as this short notice of the investigations of M. André is given mainly as an introduction to a second paper on a kindred subject.